

Description

METHOD OF INSTALLING STATIONARY BLADES OF A TURBINE AND TURBINE STRUCTURE HAVING A RADIAL LOADING PIN

BACKGROUND OF INVENTION

[0001] The present invention relates to loading pins for reaction nozzles and, more particularly, to improved loading pin configurations for securing the reaction nozzles against the retaining surfaces of the carrier with sufficient force to maintain the design amount of twisting in the airfoil section.

[0002] A conventional turbine structure includes a rotor having a plurality of rotating blades (buckets) mounted thereto. The blades are mounted in rows to extend radially outward from an outer surface of the rotor. Typically, the blades in a given row are identical to each other but the rotating blades of one row will differ in length and/or

shape from those of the other rows spaced therefrom. Each rotating blade has a foil portion that extends radially outwardly from the rotor and a base portion for mounting the blade to the rotor. To that end, the base portion includes a root received in a correspondingly shaped groove.

[0003] A stationary casing is coaxially supported around the rotor and has a plurality of stationary blades (nozzles) arranged in rows to alternate with the rows of rotating blades. All stationary blades include a foil portion extending from the inner surface of the stationary casing and a base portion including a root for being received in a corresponding groove of the stationary casing.

[0004] The root of the stationary blade and/or the groove of the stationary housing will be provided with a notch or recess to define a space between the root of the stationary blade and the groove. It is conventional to provide a caulking material or loading pin in the space defined by the notch and/or recess to interconnect the casing and root. Conventionally, the loading pin is formed from brass and is made by machining a surface onto a piece of round stock along its axis so that the pin has a constant cross-section that is generally "D" shaped along its entire length. Thus,

conventional loading pins are straight with a machined surface parallel to the longitudinal axis of the pin.

SUMMARY OF INVENTION

[0005] Integral cover reaction nozzles have been designed to maintain an assembled pre-twist that we have recognized cannot be achieved with the previous, conventional nozzle radial loading pin designs. Thus, the invention provides a wedge-like nozzle radial loading pin, preferably formed from steel, that contacts the bottom of a reaction nozzle along a graduated, that is inclined or stepped, surface. This contact will secure the reaction nozzle radially inward against the retaining surface of the carrier dovetail with sufficient force to maintain the designed airfoil pre-twist. Two embodiments of the improved radial loading pin of the invention are described and illustrated by way of example herein below.

[0006] In a first embodiment, the graduated surface is defined as a continuous taper made by machining a substantially continuously inclined surface into a piece of round stock, along its axis, such that the cross-section through any point of the pin is shaped by the letter "D". The machined surface is made at an angle to the axis of the pin to create a substantially continuously tapered face that mates with

a generally correspondingly tapered surface on the bottom of the reaction nozzle.

[0007] In an alternative embodiment, rather than a substantially continuous inclined surface, the loading pin comprises one or more discrete steps. More specifically, in an exemplary alternate embodiment, each end of the pin is machined generally parallel to the pin center line but at a different height from the pin centerline, creating two distinct surfaces and a length of machined surface at a slight angle is provided to interconnect the two flat machined surfaces.

[0008] Thus, the invention may be embodied in a method of installing stationary blades of a turbine comprising: arranging a plurality of stationary blades in a plurality of rows with each stationary blade of a row having a root and an airfoil portion, the stationary blades of a row being mounted by the roots in an annular groove provided in a turbine casing, each annular mounting groove having two opposite sidewalls and a bottom wall at least one of the root of the stationary blades and a wall of said mounting groove defining a recess; inserting a loading pin in the recess, between each said root and the groove, thereby keying the stationary blade root to the casing, said loading

pin comprising a part-circumferential wall portion, generally corresponding in cross-sectional shape to cross-sectional shape of said recess, and a graduated wall portion, so that said pin is generally wedge-shaped.

[0009] The invention may also be embodied in a turbine structure comprising: a rotor having a plurality of rotating blades or buckets mounted thereto, the blades being mounted in rows to extend radially outward from an outer surface of the rotor; a stationary casing is coaxially supported around the rotor and having a plurality of stationary blades or nozzles arranged in rows to alternate with the rows of rotating blades, at least some of said stationary blades including a foil portion extending from an inner surface of the stationary casing and a base portion including a root for being received in a corresponding groove of the stationary casing; at least one of the root of the stationary blade and the groove of the stationary housing including a recess defining a space between the root of the stationary blade and the groove; a loading pin disposed in the space defined by the recess to interconnect the casing and root, said loading pin comprising a part-circumferential wall portion, generally corresponding in cross-sectional shape to cross-sectional shape of said re-

cess, and a graduated wall portion, so that said pin is generally wedge-shaped.

BRIEF DESCRIPTION OF DRAWINGS

[0010] These and other features and advantages of this invention, will be more completely understood and appreciated by careful study of the following more detailed description of the presently preferred exemplary embodiments of the invention taken in conjunction with the accompanying drawings, in which:

[0011] FIGURE 1 is a schematic longitudinal section of stationary and moving blades of a turbine;

[0012] FIGURE 2 is an elevational view of a loading pin provided in accordance with an exemplary embodiment of the invention;

[0013] FIGURE 3 is an end view taken from the right of FIGURE 2;

[0014] FIGURE 4 is an elevational view of a loading pin provided in accordance with an alternate embodiment of the invention;

[0015] FIGURE 5 is an end view taken from the right of FIGURE 4;

[0016] FIGURE 6 is a cross-sectional view, looking down the turbine centerline, showing the pin of FIGURE 2 installed between a nozzle and casing; and

[0017] FIGURE 7 is a cross-section view looking down the turbine centerline, the pin of FIGURE 4 installed between a nozzle and casing.

DETAILED DESCRIPTION

[0018] Elastically pre-stressed blades installed under controlled conditions display excellent damping characteristic and are in the position of absorbing dynamic stresses under all operating conditions without endangering their long-term reliable life span. For blades with a sufficient amount of pre-stress, there is no frictional wear and no blade loosening. Therefore, it is important to maintain the prescribed pre-stress.

[0019] Thus, a design objective is that all installed blades are twisted inside the corresponding groove by a specific twist. The configuration of the nozzle airfoil and the dimensions of the root are selected so that the blade can assume the position inside the groove which is defined by the design criteria.

[0020] A loading pin provided in accordance with the present invention provides a wedge contact for radially loading the nozzle to secure the nozzle radially inward against the retaining surface of the carrier dovetail with sufficient force to maintain the designed airfoil pre-twist.

[0021] FIGURE 1 schematically illustrates in longitudinal section two stages of a turbine structure. In the illustrated structure, a generally part cylindrical or U-shaped recess 10 is defined at the base of each nozzle root 12 receiving groove 14. A loading pin 16 is inserted into this recess between the casing 18 and the nozzle 20 for locking these parts with the nozzle in its pre-twisted disposition. To assuredly lock each nozzle and maintain its pre-twist, in an embodiment of the invention, the loading pin 16,116 is generally wedge shaped having a part cylindrical wall portion 22,122,222 and a graduated, i.e., inclined or stepped, wall portion 24,124,224.

[0022] In a first embodiment, illustrated in FIGURE 2, the loading pin 116 has a wall portion 124 that is substantially continuously inclined from a first, insert end 126 to a second, proximal end 128 to define a generally tapered or wedge shaped pin 116. As will be understood from FIGURE 3, the cross sectional area of the loading pin adjacent the distal, insert end is less than the cross sectional area of the loading pin adjacent said proximal end. Although wall portion 124 is illustrated as a continuously tapered surface, a wall portion comprising a plurality of steps so as to define an effectively continuously inclined surface would

be functionally equivalent thereto.

[0023] A groove 130 is optionally defined longitudinally of the loading pin defining a part circular recess extending from the proximal to the distal ends of the pin. The groove allows the pin material to swage or upset from its original surfaces, thereby increasing the contact area between the pin and the nozzle. The groove also allows, e.g., insertion of a pin removal tool (not shown) so that the pin may be engaged and displaced proximally even if fully inserted below a respective nozzle 120. Although a part circular groove 130 is illustrated it is to be understood that the cross-sectional shape of this groove is non-critical and a V-shaped, rectangular or other groove configuration could be provided without departing from this invention.

[0024] As will be appreciated, the insertion of the tapered loading pin 116 illustrated in FIGURE 2 into recess 110, between the nozzle root 112 and the root groove (carrier dovetail) 114 of the casing, lifts the nozzle slightly from the groove base. This will secure the reaction nozzle radially inward against the retaining surface of the carrier dovetail with sufficient force to maintain the designed airfoil pre-twist. To maximize the surface-to-surface contact between the loading pin and its respective nozzle(s),

in an exemplary embodiment, a corresponding portion of the nozzle root 112 is machined to define an inclined surface 132 generally corresponding to the incline of the wall portion 124 of the loading pin 116 so that insertion of the loading pin yields an inclining surface to inclined surface wedge displacement. To ensure that the loading pin will maintain its shape and the corresponding lock of the nozzle with respect to the casing, in an exemplary embodiment, the loading pin is formed from steel.

[0025] An alternate embodiment of the invention is illustrated in FIGURES 4–5 and 7, rather than a tapered or substantially continuously inclined surface, wall portion 224 is comprised of discrete stepped portions. In the illustrated embodiment, a single step is defined along the length of the pin 216. More specifically, in this end, the pin is machined to define a flat nozzle engaging surface 234,236 adjacent each end 226,228, said surfaces being generally parallel to the longitudinal axis of the loading pin, and the loading pin 216 is machined to define an inclined transition or step 238 between the parallel surfaces 226,228. As illustrated by dashed line 240, the offset between flat surfaces 226,228 is limited. As also illustrated, a cutout 242 at the nozzle root may be provided to facilitate pin insertion.

[0026] A groove 230 is optionally defined longitudinally of the loading pin defining a part circular recess extending from the proximal end 228 to the distal end 226 of the pin 216. As in the first described embodiment, the groove 230 is provided to allow the pin material to swage or upset from its original surfaces, thereby increasing the contact area between the pin and the nozzle. The groove also allows, e.g., insertion of a pin removal tool (not shown) so that the pin may be engaged and displaced proximally even if fully inserted below a respective nozzle 212. As mentioned above, although a part circular groove 230 is illustrated for pin retrieval it is to be understood that the cross-sectional shape of this groove is non-critical and a V-shaped, rectangular or other groove configuration could be provided without departing from this invention.

[0027] As will be appreciated, the insertion of the tapered loading pin 216 illustrated in FIGURE 4 into recess 210, between the nozzle root 212 and the root groove 214 of the casing, lifts the nozzle slightly from the base base of the dovetail groove 214 to effectively lock the nozzle in its prescribed pre-twisted configuration. Once again, to ensure that the loading pin will maintain its shape and the corresponding lock of the nozzle with respect to the cas-

ing, in an exemplary embodiment, the loading pin is formed from steel.

[0028] As noted above, it is to be understood that while a continuously inclined surface and a single stepped surface are illustrated as embodiments of the invention, the inclined surface need not be continuously inclined but can be provided as a series of discrete steps. Furthermore, the discrete flats 226,228 of the steps may themselves be provided as surfaces that are generally parallel to the longitudinal axis of the pin as illustrated in FIGURE 4, or may be inclined themselves. Moreover, while in the illustrated embodiment, the transition 238 between discrete steps is provided as an inclined surface, it is to be understood that in the alternative, a plurality of discrete, generally perpendicular radial steps may be provided, whereby the cross-sectional area of the pin is increased from the distal end to the proximal continuously or in steps.

[0029] While the invention has been described in connection with what is presently considered to be the most practical and preferred embodiment, it is to be understood that the invention is not to be limited to the disclosed embodiment, but on the contrary, is intended to cover various modifications and equivalent arrangements included within the

spirit and scope of the appended claims.